

## SUMMARY PAGE

## PROBLEM

To determine the effects of extreme cold on eyes wearing contact lenses

## FINDINGS

Cold does not appear to have a deleterious effect on rabbit eyes wearing contact lenses.

## APPLICATIONS

If additional research on humans is supportive, the data suggest contact lenses can probably be safely worn in the cold. Additionally, contact lenses might provide some protection to the eyes from wind-driven ice and snow particles.

## ADMINISTRATIVE INFORMATION

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## Contact Lenses in Extreme Cold Environments: Response of Rabbit Corneas

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### Abstract

Contact lenses are worn by many individuals in military and civilian populations. Anecdotal reports have described contact lenses "sticking" and "freezing" to the eye during extreme cold conditions. However, some articles indicate the advantages of wearing contact lenses in cold environments. Military operations frequently take place in cold regions; therefore, we need to know whether contact lenses can be worn safely in extreme cold. Rabbits were fitted with hard (polymethyl methacrylate) contact lenses and exposed to  $-28.9^{\circ}\text{C}$  temperatures with winds up to 78 mph (125 km/hr) for 3-hr periods. The wind-chill factor in these conditions exceeded  $-67.8^{\circ}\text{C}$ . No effects of the cold or contact lenses were seen in 85% of the eyes. A few of the eyes, both with contact lenses and without, showed mild superficial fluorescein staining of the cornea which cleared within a few hours after exposure. Histologic examination of the corneas revealed no abnormalities attributable to the cold. Inasmuch as this study showed that rabbits wearing contact lenses in extreme cold suffered no acute deleterious effects to the eyes, the research can be expanded to include human subjects.

Key Words: corneal damage, cold temperatures, contact lenses, rabbits, histology

Today's rapid deployment military force must be prepared to see action in a wide range of geographical areas and climates. For the military person wearing glasses in arctic or subarctic regions, a number of problems exist. In the cold, spectacle lenses continually fog, and frames become brittle and break. Glasses are apt to be lost in the snow. These problems also occur with the wearing of goggles and may cause vision to be significantly reduced. Contact lenses offer a possible solution.

Between 30 and 60% of those in the

Armed Forces wear glasses and 3 to 5% of military personnel wear contact lenses. Anecdotal reports have described contact lenses "sticking" or "freezing" to the eye during extreme cold conditions. Therefore, it is important to know the effects of extreme cold upon the cornea and its relation to contact lens wear.

There are a number of reports in the literature showing the effects of cold on the eye. Freezing of the cornea has been noted in flyers and soldiers.<sup>1</sup> Corneal temperature has been shown to be a function of ambient temperature and body temperature,<sup>2</sup> and continues to decrease with time in a cold chamber in a manner consistent with exponential decay. Cold seems to promote

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healing of corneal burns,<sup>3</sup> but extreme cold in the form of liquid nitrogen or a cryoprobe results in corneal endothelial changes<sup>4</sup> or increased aqueous protein.<sup>5</sup>

Inhabitants of cold regions have been the subject of studies on the eye. A type of corneal degeneration known as Labrador keratopathy has been described in these populations by a number of authors.<sup>6-9</sup> It has been found most often in Eskimos, Lapps, and to a lesser extent in Chere- misses. The disease results in the formation of fine, gray, opaque particles at the level of Bowman's membrane, and these may extend into the stroma as the condition worsens. It is bilateral, symmetrical, and limited to the intrapalpebral aperture. Vascularization does not occur, nor does staining of the epithelium. Severe forms of the degeneration are directly related to increased age. The only symptom is progressive loss of vision. Because it occurs more frequently in Lapps and Eskimos than in Chere- misses, it has been postulated the condition is caused by excess ultraviolet light<sup>7,9</sup> due to the latitude at which the former two cultures live.

Other studies suggest that some cold injuries to the eye could be prevented by contact lenses. Cross-country skiers sometimes suffer epithelial injury and reduced visual acuity.<sup>10</sup> This occurred after a 50-min ski race in  $-16^{\circ}\text{C}$  temperatures in a no-wind, no-snow falling condition. Possibly these acute ocular changes were due to drying of the eye or to breakup of the tear film which might have been prevented by contact lenses. Eskimos driving snowmobiles may develop central corneal lesions which stain with fluorescein.<sup>9</sup> These are believed to be due to ice and snow damage to the cornea. In the same study, two individuals who wore contact lenses showed no corneal damage. During the 1975 British assault on Mount Everest, five climbers were fitted with continuous wear hydrophilic contact lenses. Two of the climbers wore the soft contact lenses all the time for over 50 days on the mountain up to an altitude 7,925 m (26,000 ft) with no observed corneal problems.<sup>11</sup> Of the other three, one felt his visual acuity was better with his glasses, one was poorly motivated and lost two pairs of lenses, and the other just preferred glasses although he had no trouble with his contact lenses.

My study sought to determine whether or not contact lenses can be used safely as an eye protective device in the cold.

## METHODS

Eighteen female New Zealand white rabbits weighing between 2.7 and 3.2 kg (6 and 7 lb) were selected to wear hard (polymethyl methacrylate) contact lenses. Lenses were fitted according to keratometric readings and the fluorescein pattern, using trial lenses. The lenses were fitted either with the posterior surface of the contact lens parallel to the anterior surface of the cornea (on "K") or with the contact lens radius of curvature slightly shorter than that of the cornea (steeper than "K"). One eye of each rabbit wore a contact lens and the other was the control eye. The animals received the cold exposure in an environmental chamber; five of the animals were exposed twice. All the exposures were for three hours at  $-28.9^{\circ}\text{C}$ . Wind conditions were either no wind (four exposures) or high wind (19 exposures) ranging from 74 to 125 km/hr (46 to 78 mph), depending upon the location of the animal in the cold chamber.

Periodically during the exposure period, I monitored the fit of the contact lenses. Immediately after completion of the exposure, the corneas and contact lenses were evaluated with fluorescein by using a hand-held Burton lamp and slitlamp examination. Eleven of the animals were killed with intraperitoneal sodium pentobarbital and the eyes were enucleated. Three of the rabbits were observed for 24 hr and three for 48 hr before undergoing enucleation. For histologic examination of the corneas, the eyes were fixed whole in aqueous 10% formalin with regular changes in formalin for 72 hr, followed by 24 hr in 50% (volume) aqueous ethanol. The globes were sectioned sagittally sparing the lens and the sections embedded in Bioloid (paraffin) after processing. The blocks were sectioned at four micrometers to provide a transection of the globe through the cornea. Slides were examined after hematoxylin and eosin staining.

## RESULTS

Throughout the cold exposure, the animals appeared to have no difficulty wearing the contact lenses. In the high-wind condi-

tions, the rabbits narrowed their palpebral fissures to approximately 6 mm. The blink rate did not increase appreciably. The contact lenses never appeared to be "stuck" or "frozen" to the eye. Some rabbits produced more tears which froze to the fur of the lower lid. This usually occurred bilaterally with no appreciable difference between the two eyes, and did not interfere with contact lens fit.

Examination of the corneas with the Burton lamp and fluorescein immediately after the cold exposures revealed three animals with staining of the experimental eye and four with staining of the control eye. Slitlamp examination of the corneas showed the staining was confined to the superficial corneal epithelium. All the staining was mild and superficial. The staining was confined to the portion of the cornea not covered by the lids during the cold exposure. No corneal edema was noted during biomicroscopy. The corneas became clear within a few hours after the cold exposure. There was no detectable permanent damage to any of the eyes. It is not possible to be sure whether the epithelial damage was due to the contact lenses, or to the manipulation of the lids. Histopathologic examination of the corneal sections by light microscopy revealed no corneal changes which could be attributed to either the contact lenses or the cold. Disruption of the corneal epithelium did not occur in either the test eyes or the control eyes; in particular, the basal cell layer showed no reactive changes. There was no alteration of the columnar or cuboidal cell morphology nor basal cell migration such as would be expected if epithelial cryoinjury induced the typical injury response. Initially, we planned to use vital dye staining to direct the selection of injured corneal epithelium for histological examination; however, it should be noted that only large lesions would likely be found in this fashion. The dyes revealed no injury—large, geographic, punctate, or otherwise; therefore, this technique was not used.

## DISCUSSION

In the above experiment, the combination of temperature and wind produced wind-chill factors in the vicinity of  $-67.8^{\circ}\text{C}$ , yet this acute exposure of the cornea to

cold with and without hard contact lenses did not produce detectable harmful effects to the eyes of rabbits. Because the decrease in corneal temperature follows approximately an inverse exponential curve<sup>2</sup> with an asymptote at about  $30^{\circ}\text{C}$ , it is unlikely that freezing temperatures would be reached even under the most extreme conditions which man would experience in the field. Although anterior chamber depth and corneal thickness are two factors possibly affecting corneal temperature,<sup>12</sup> it is more likely that aqueous circulation in the anterior chamber plays a more important role in maintaining corneal temperature above the freezing point.

The previously reported instances of contact lenses sticking to the eye are more likely due to a dry eye problem as a result of low humidity and wind in cold climates than to freezing. The lack of injury to rabbit corneas in the cold suggests that contact lenses may be acceptable and may even offer protection to the eyes from wind-driven ice and snow in cold environments. Research will be pursued in this area.

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